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Original article

Determining the relationship between physical status and musculoskeletal injuries in children: a cohort study

Yohei Tomaru[1], Hiroshi Kamada[1], Yuta Tsukagoshi[1], Shogo Nakagawa[1], Kenta Tanaka[1], Ryoko Takeuchi[2], Yuki Mataki[2], Mio Kimura[1], Shumpei Miyakawa[1], and Masashi Yamazaki[1]

[1]*Department of Orthopaedic Surgery, Faculty of Medicine, University of Tsukuba, Japan*
[2]*Department of Orthopaedic Surgery, Ibaraki Prefectural University of Health Sciences Hospital, Japan*

Abstract

Background: In Japan, in 2016, the School Health and Safety Act was revised and examination of extremities in addition to scoliosis became mandatory. Musculoskeletal examinations were subsequently started using a mark sheet-type questionnaire. In the present study, we aimed to analyze the relationship between physical findings and musculoskeletal problems and propose a preventive strategy for musculoskeletal injuries.
Methods: In 2017, a total of 4,073 elementary and middle school students underwent direct musculoskeletal examination. In a direct examination, the following elements were included: torticollis; scoliosis; stiffness of the shoulder, elbow, hip, knee, and ankle; flexion and extension in standing position; flat foot; hallux valgus; and alignment of the upper and lower extremities. Of the 4,073 students who underwent direct examination in early 2017, only 3,754 were able to complete the mark sheet-type questionnaires in early 2018. A prospective longitudinal analysis of the data gathered was performed.
Results: A total of 396 (11%) students had injuries. The ankle sprain/non-ankle sprain group comprised 119 (3%)/3,635 (97%) students, while the fracture/non-fracture group comprised 105 (2.8%)/3,650 (97.2%) students, respectively. Comparing the sprain group with the non-sprain group, ankle stiffness significantly correlated with ankle sprain in the univariable and multivariable analyses. Injuries occurred more frequently among boys, older students, students with stiff bodies, and students who were involved in sports activities of longer duration.
Conclusion: Ankle stiffness was assumed to be a risk factor for ankle sprain. Stretching of the ankle might be effective for preventing ankle sprain. However, further interventional studies are needed to confirm this finding.

Key words: children, physical findings, musculoskeletal injuries, sports

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Introduction

In Japan, the musculoskeletal examination is performed to assess the status of the musculoskeletal system. Musculoskeletal examination is recommended by the school health and safety law in Japan[1)]. Internal medicine was introduced in Japan in 1897. Subsequently, scoliosis examination first started in 1958. During that period, scoliosis due to spinal caries has been a huge problem. Hence, screening for scoliosis is usually performed prior to the assessment of extremities. In 1994, with the increase in the incidence of sports injuries, the following statement was added to the school health and safety law: “Be aware of the condition of the extremities and examine the status of not only scoliosis but also that of extremities”. However, as this was not compulsory, the implementation of the examination of extremities was insufficient. In 2016, the school health and safety law was revised and examination of extremities became mandatory.

Furthermore, to increase the examination scale, musculoskeletal examination using mark sheet-type questionnaire

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Correspondence: Yohei Tomaru, MD, Department of Orthopaedic Surgery, Faculty of Medicine, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8575, Japan
E-mail: maruto222@tsukuba-seikei.jp

has started in all elementary and junior high schools in two cities in Ibaraki prefecture (Figure 1).

In Japan, the increasing number of injuries, including fractures, has become a social problem. Moreover, a correlation between increasing deprivation and incidence of fractures has been reported[2]. The incidence of bone fracture more than doubled from 1970 through 2000[3]. Torii et al. hypothesized that the increasing incidence of fractures is possibly due to the decline in physical strength, bone density, and the ability to avoid crisis[3]. Musculoskeletal examination is performed for early detection and early treatment of musculoskeletal problems. In addition, musculoskeletal examination could provide recommendations for prevention of musculoskeletal problem based on the results of data analysis. To develop precautionary measures for injuries, it is important to know the relationship between physical status and musculoskeletal problems. We reported cross-sectional data of the epidemiology of musculoskeletal problem and the accuracy of mark sheet-type questionnaire[4]. However, our previous study was limited as it reported cross-sectional data instead of longitudinal data[4]. As musculoskeletal examination has been performed since 2016, we are able to collect not only cross-sectional data but also longitudinal data; hence, longitudinal analysis became possible. In the present study, we desired to determine the problems with analyzing longitudinal data from 2017 to 2018. Therefore, this study aimed to report the etiology of musculoskeletal injuries among students in elementary and junior high schools in Japan, to analyze the relationship between physical findings and musculoskeletal problem, and to propose corresponding musculoskeletal injury preventive measures.

Patients and Methods

We performed a prospective longitudinal observation study (cohort study). In the early 2017, 4,073 first-grade elementary to second-grade junior high school students underwent direct musculoskeletal screening, which was performed by an orthopedic surgeon. A direct examination was conducted by seven orthopedic surgeons. To unify the standards, a final decision was made by a designated orthopedic surgeon. In the direct examination, the following elements were included: torticollis; scoliosis; range of motion (ROM) of the shoulders, elbows, hips, knees, and ankles; stand flexion; stand extension; flat foot; hallux valgus; and alignment of the upper and lower extremities.

Abnormal findings were defined as follows: (1) *torticollis*, head tilt while standing straight, limited neck ROM, and abnormal tension of the sternocleidomastoid; (2) *scoliosis*, shoulder and/or scapular height asymmetry, rib hump, and/or lumbar hump when bending forward while in standing position; (3) *shoulder stiffness*, unable to fully raise one's arm; (4) *stiffness of the elbow*, unable to touch one's shoulder using own fingers; (5) *stiffness of the hips, knees, and ankles*, unable to execute a full squat with the heels on the floor; (6) *stand flexion*, unable to touch the floor in the standing position with knees straight; (7) *stand extension*, back pain occurs during full lumbar extension; (8) *flat foot*, loss of foot arch; (9) *hallux valgus*, valgus deformity of the hallux; (10) *alignment of upper extremities*, a valgus angle (carrying angle) of the extended elbow of 20 degrees or more was defined as valgus elbow and 0 degrees or less as varus elbow; (11) *alignment of lower extremities*, a gap of two fingers or more between the knees when standing straight was defined as varus knee (O leg) and a gap of two fingers or more between the medial malleolus of the ankle was defined as valgus knee (X leg); and (12) *general joint laxity*, evaluated based on the information collected from the questionnaire. The Beighton index was used to evaluate joint laxity[5], and a Beighton index of ≥5 points was defined as abnormal.

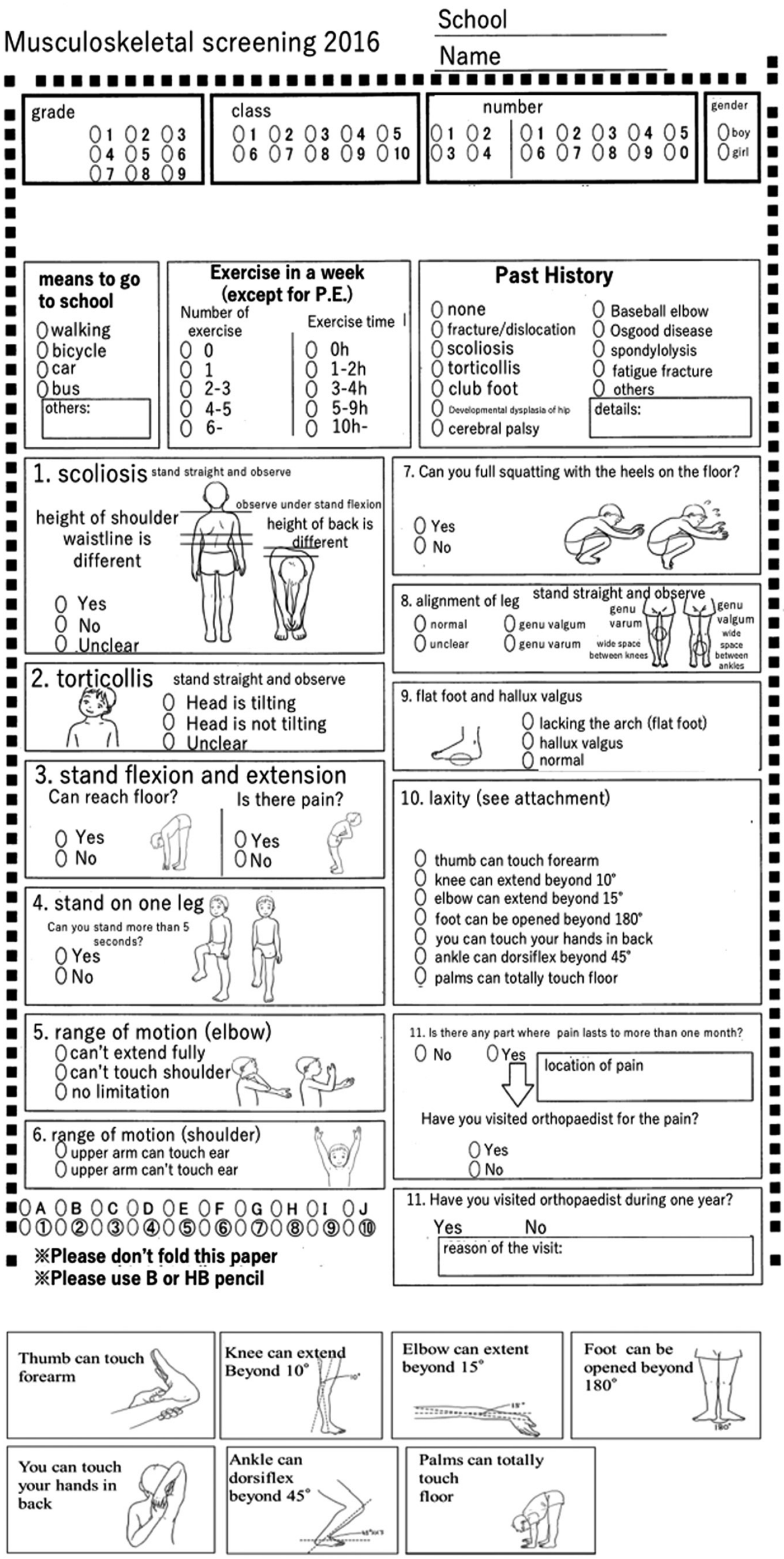
Of the 4,073 students who underwent direct examination in early 2017, 3,754 students answered the mark sheet-type questionnaire in early 2018. The questionnaire comprised items that assess the patient's history of injury in the previous year. A direct examination was performed to identify the physical conditions of the students in early 2017, while the questionnaire survey was performed to identify the incidence of musculoskeletal problem in 2017. Subsequently, a prospective longitudinal analysis was performed based on this information.

The students were divided into injury groups and non-injury groups and analyzed. Of all types of injuries, ankle sprain and fractures frequently occur. Since other injuries occurred infrequently, it was impossible to perform an accurate analysis. In addition to analyzing the overall injury/non-injury and ankle sprain/non-ankle sprain groups, the fracture/non-fracture groups were also analyzed.

Due to the high incidence rate, fracture and ankle sprain were analyzed individually. Meanwhile, joint dislocation, fatigue fracture, Osgood disease, and spondylosis had low incidence; hence, patients with these conditions were included in the "injury" group and were analyzed.

Statistical analysis

Age, sex, physical status at the time of direct examination, time spent on exercise and on physical education class in a week, and the type of exercise most predominantly performed on a daily basis were compared between the two groups (injury/non-injury groups, ankle sprain/non-ankle sprain groups, and fracture/non-fracture groups) using χ^2 test, residual analysis, and Student's t-test, respectively. A *P*-value of less than 0.05 was considered significant. Elements that had significant correlation with injury, fracture, and ankle sprain in the χ^2 test or Student's t-test were chosen as explanatory variables for the multivariable statistical analysis. Meanwhile, fracture, ankle sprain, and injury were



School
Musculoskeletal screening 2016
Name

grade: 1 2 3 4 5 6 7 8 9
class: 1 2 3 4 5 6 7 8 9 10
number: 1 2 3 4 | 1 2 3 4 5 6 7 8 9 0
gender: boy girl

means to go to school
walking
bicycle
car
bus
others:

Exercise in a week (except for P.E.)
Number of exercise: 0 / 1 / 2-3 / 4-5 / 6-
Exercise time: 0h / 1-2h / 3-4h / 5-9h / 10h-

Past History
none
fracture/dislocation
scoliosis
torticollis
club foot
Developmental dysplasia of hip
cerebral palsy
Baseball elbow
Osgood disease
spondylolysis
fatigue fracture
others
details:

1. scoliosis stand straight and observe
height of shoulder waistline is different
observe under stand flexion
height of back is different
Yes
No
Unclear

2. torticollis stand straight and observe
Head is tilting
Head is not tilting
Unclear

3. stand flexion and extension
Can reach floor? Yes / No
Is there pain? Yes / No

4. stand on one leg
Can you stand more than 5 seconds?
Yes
No

5. range of motion (elbow)
can't extend fully
can't touch shoulder
no limitation

6. range of motion (shoulder)
upper arm can touch ear
upper arm can't touch ear

A B C D E F G H I J
⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
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7. Can you full squatting with the heels on the floor?
Yes
No

8. alignment of leg stand straight and observe
normal
unclear
genu valgum
genu varum
genu varum wide space between knees
genu valgum wide space between ankles

9. flat foot and hallux valgus
lacking the arch (flat foot)
hallux valgus
normal

10. laxity (see attachment)
thumb can touch forearm
knee can extend beyond 10°
elbow can extend beyond 15°
foot can be opened beyond 180°
you can touch your hands in back
ankle can dorsiflex beyond 45°
palms can totally touch floor

11. Is there any part where pain lasts to more than one month?
No
Yes
location of pain
Have you visited orthopaedist for the pain?
Yes
No

11. Have you visited orthopaedist during one year?
Yes No
reason of the visit:

Thumb can touch forearm
Knee can extend Beyond 10°
Elbow can extent beyond 15°
Foot can be opened beyond 180°
You can touch your hands in back
Ankle can dorsiflex beyond 45°
Palms can totally touch floor

Figure 1 Musculoskeletal screening 2016.

Table 1 Characteristics of patients in the injuries and non-injury group

	Injury	Non-injury	Statistical analysis	*P*-value
n	396/3,754 (11%)	3,358/3,754 (89%)	-	-
Boy	238/396 (60%)*	1,693/3,358 (50%)	χ^2 test	*P*<0.001
Girl	158/396 (40%)	1,664/3,358 (50%)		
Age	11.7 (7.0–15.0)*	10.6 (7.0–15.0)	Student t-test	*P*<0.001
Exercise time (hr/week)	5.2 (0.0–10)*	3.1 (0.0–10.0)		*P*<0.001
Physical status at 2017 examination				
Bow leg	220/396 (7.8%)	199/3,358 (6.0%)	χ^2 test	n.s.
Knock knee	286/396 (8.1%)	266/3,358 (8.0%)		
Flat foot	83/396 (21%)	659/3,358 (20%)		n.s.
Hip stiffness	3/396 (0.8%)	14/3,358 (0.4%)		n.s.
Knee stiffness	4/396 (1.0%)	5/3,358 (0.1%)		n.s.
Ankle stiffness	38/396 (9.6%)*	219/3,358 (6.5%)		*P*<0.05
Shoulder stiffness	0/396 (0.0%)	6/3,358 (0.2%)		n.s.
Elbow stiffness	4/396 (1.0%)*	11/3,358 (0.3%)		*P*<0.05
Stand flexion	65/396 (16%)	610/3,358 (18%)		n.s.
Stand extension	10/396 (2.5%)	55/3,358 (1.6%)		n.s.
General joint laxity	100/396 (25%)	997/3,358 (30%)		n.s.
Type of sports activity				
Soccer	67/396 (19%)*	315/3,358 (9.6%)	Residual analysis	*P*<0.01
Tennis	16/396 (4.5%)	246/3,358 (7.5%)*		*P*<0.05
Dance	11/396 (3.1%)	109/3,358 (3.3%)		n.s.
Basketball	37/396 (10%)*	89/3,358 (2.7%)		*P*<0.01
Badminton	13/396 (3.7%)*	34/3,358 (1%)		*P*<0.01
Kendo	16/396 (4.5%)*	39/3,358 (1.2%)		*P*<0.01
Swimming	54/396 (15%)	830/3,358 (25%)*		*P*<0.01
Track & Field	17/396 (4.8%)*	50/3,358 (1.5%)		*P*<0.01
Baseball	22/396 (6.2%)*	93/3,358 (2.8%)		*P*<0.01
No sport	103/396 (29%)	1,487/3,358 (45%)*		*P*<0.01

*: significantly high (*P*<0.05, student t-test, χ^2 test, residual analysis). n.s.: not significant.

assigned as purpose variables, and nominal logistic regression analysis was performed. All statistical analyses were carried out using JMP version 13.0.0 (SAS Institute Inc., USA).

Results

A total of 396 (10.5%)/3,358 (89.5%), 119 (3.2%)/3,635 (96.8%), and 105 (2.8%)/3,650 (97.2%) students were included in the injury/non-injury, ankle sprain/non-ankle sprain, and fracture/non-fracture groups, respectively. Approximately 92% (3,754/4,073) of the study participants were followed up. The follow-up period was 1 year. Details are shown in Tables 1–3.

In the univariable analysis, a significant difference was observed between the injury group and non-injury group in terms of age; sex; stiffness of the knees, ankles, and elbows; exercise time; and type of exercise (*P*<0.05, χ^2 test, Student's t-test). In the nominal logistic regression analysis with age; sex; stiffness of the knees, ankles, and elbows; exercise time; and exercise type as explanatory variables and injury as purpose variable, age, sex, stiffness of the ankles and elbows, exercise time, and type of exercise significantly correlated with injury. Only knee stiffness was excluded in the nominal logistic regression analysis. With regard to exercise type, the number of soccer, basketball, badminton, kendo, track and field, and baseball players in the injury group was significantly higher than that in the non-injury group. By contrast, the number of tennis players, swimmers, and non-sport players in the injury group was significantly lower than that in the non-injury group (χ^2 test, residual analysis, *P*<0.05).

The univariate analysis showed a significant difference between the sprain group and non-sprain group in terms of age, stiffness of the ankles and elbows, stand flexion, and exercise type (*P*<0.05, χ^2 test, Student's t-test).

In the nominal logistic regression analysis with age, stiffness of the ankles and elbow, stand flexion, and exercise type as explanatory variables and ankle sprain as purpose variable, stiffness of the ankles was strongly correlated with ankle sprain (*P*<0.005). In addition, age and stand flexion significantly correlated with ankle sprain (*P*<0.05). With re-

Table 2 Characteristics of Patients in the Ankle Sprain and Non-Ankle Sprain Group

	Ankle sprain	Non-ankle sprain	Statistical method	*P*-value
n	119/3,754 (3.2%)	3,635/3,754 (96.8%)	-	-
Boy	60/119 (50%)	1,871/3,635 (52%)	χ^2 test	n.s.
Girl	59/119 (50%)	1,763/3,635 (49%)		
Age	12.2 (7.3–15.0)*	10.6 (7.0–15.1)	Student t-test	P<0.001
Exercise time (hr/week)	5.6 (0–10.0)*	3.3 (0–10.0)		
Physical status at examination in 2017				
Bow leg	10/119 (8.0%)	220/3,635(6.1%)	χ^2 test	n.s.
Knock knee	8/119 (7.0%)	286/3,635 (7.9%)		
Flat foot	27/119 (23%)	715/3,635 (20%)		n.s.
Hip stiffness	1/119 (0.8%)	16/3,635 (0.4%)		n.s.
Knee stiffness	1/119 (0.8%)	8/3,635 (0.2%)		n.s.
Ankle stiffness	14/119 (12%)*	243/3,635 (6.7%)		*P*<0.05
Shoulder stiffness	0/119 (0.0%)	6/3,635 (0.2%)		n.s.
Elbow stiffness	2/119 (1.7%)*	13/3,635 (0.4%)		*P*<0.05
Stand flexion	12/119 (10%)	663/3,635 (18%)*		*P*<0.05
Stand extension	3/119 (2.5%)	62/3,635 (1.7%)		n.s.
General joint laxity	31/119 (26%)	1,066/3,635 (29%)		n.s.
Type of sports activity				
Soccer	21/119 (20%)*	361/3,635 (10%)	Residual analysis	*P*<0.01
Tennis	9/119 (8.4%)	253/3,635 (7.1%)		n.s.
Dance	3/119 (2.8%)	117/3,635 (3.3%)		n.s.
Basketball	19/119 (18%)*	107/3,635 (3.0%)		*P*<0.01
Badminton	3/119 (2.8%)	44/3,635 (1.2%)		n.s.
Kendo	3/119 (2.8%)	52/3,635 (1.5%)		n.s.
Swimming	19/119 (18%)	865/3,635 (24%)		n.s.
Track & Field	4/119 (3.7%)	63/3,635 (1.8%)		n.s.
Baseball	2/119 (1.9%)	115/3,635 (3.2%)		n.s.
No sport	24/119 (22%)	1,566/3,635 (44%)*		*P*<0.01

*: significantly high (*P*<0.05, student t-test, χ^2 test, residual analysis). n.s.: not significant.

gard to exercise type, the number of soccer and basketball players in the ankle sprain group was significantly higher than that in the non-ankle sprain group. By contrast, the number of students who were not involved in specific sports was significantly lower in the injury group than in the non-injury group (residual analysis, *P*<0.05).

The univariate statistical analysis showed a significant difference between the fracture group and non-fracture group in terms of age, sex, stiffness of the hip, exercise time, and exercise types (*P*<0.05, χ^2 test, Student's t-test). In the multivariable nominal logistic regression analysis with age, sex, stiffness of hip, exercise time, and exercise type as explanatory variable and fracture as purpose variable, only sex significantly correlated with fracture (*P*<0.001). With regard to exercise type, the number of kendo and basketball players were significantly higher in the fracture group than in the non-fracture group (residual analysis, *P*<0.05) (Table 3). General joint laxity did not correlate with overall injury, ankle sprain, and fracture.

Discussion

In this report, injuries occurred more frequently among boys; older students; students with stiff knees, ankles, and elbows; and students who are involved in sports activities of longer duration. With regard to the type of sports, soccer, basketball, badminton, kendo, track and field were considered high-risk activity for ankle sprain and fracture. B contrast, tennis and swimming were considered low-risk activity for injury. Moreover, non-involvement in any sport activity except for physical education in school was considered to lower the risk of injury.

In the current study, ankle sprain occurred in 119/3,754 (3.2%) per person-years. In a systematic review by Doherty *et al.*, the incidence of ankle sprain was 52.98/1,000/year[6]. The rate reported in our study was lower than that reported by Doherty et al. Since the examinees in the present study were regular elementary and junior high school students, our number of athletes was lower than that in Doherty *et al.*'s study. The differences in examinees' background might affect the result. Fujita *et al.* reported that the incidence of

Table 3 Characteristics of Patients in the Fracture and Non-Fracture Group

	Fracture	Non-fracture	Statistical analysis	*P*-value
n	105 (2.8%)	3,650 (97.2%)	-	-
Boy	74/105 (71%)*	1,857/3,650 (51%)	χ^2 test	*P*<0.001
Girl	31/105 (30%)	1,793/3,650 (49%)		
Age	10.9 (7.0–15.0)*	10.7 (7.0–15.1)	Student t-test	*P*<0.001
Exercise time (hr)	4.6 (0.0–10.0)*	3.3 (0.0–10.0)		*P*<0.05
Physical status at examination in 2017				
Bow-legs	6/105 (5.7%)	224/3,650 (6.1%)	χ^2 test	n.s.
Knock-legs	10/105 (9.5%)	28/3,650(7.8%)		
Flat foot	24/105 (23%)	718/3,650 (19.7%)		n.s.
Hip stiffness	3/105 (2.9%)*	14/3,650 (0.4%)		*P*<0.001
Knee stiffness	0/105 (0.0%)	9/3,650 (0.2%)		n.s.
Ankle stiffness	7/105 (6.7%)	250/3,650 (6.8%)		n.s.
Shoulder stiffness	0/105 (0.0%)	6/3,650 (0.2%)		n.s.
Elbow stiffness	1/105 (1.0%)	14/3,650 (0.4%)		n.s.
Stand flexion	20/105 (19%)	656/3,650 (18%)		n.s.
Stand extension	2/105 (1.9%)	63/3,650 (1.7%)		n.s.
General joint laxity	33/105 (31%)	1,065/3,650 (29%)		n.s.
Type of sports activity				
Soccer	14/105 (16%)	368/3,650 (10%)	Residual analysis	n.s.
Tennis	2/105 (2.2%)	260/3,650 (7.3%)		n.s.
Dance	3/105 (3.3%)	120/3,650 (3.3%)		n.s.
Basketball	8/105 (8.9%)*	119/3,650 (3.3%)		*P*<0.05
Badminton	2/105 (2.2%)	45/3,650 (1.3%)		n.s.
Kendo	5/105 (5.6%)*	50/3,650 (1.4%)		*P*<0.05
Swimming	15/105 (17%)	869/3,650 (24%)		n.s.
Track & Field	3/105 (3.3%)	64/3,650 (1.8%)		n.s.
Baseball	6/105 (6.7%)	109/3,650 (3.1%)		n.s.
No sport	32/105 (36%)	1,558/3,650 (44%)		n.s.

*: significantly high (*P*<0.05, student t-test, χ^2 test, residual analysis). n.s.: not significant.

ankle sprain in Japanese men college soccer players was 2.40/1000 athlete-exposure[7]. In a study by Waterman *et al.*, the incidence of ankle sprain was 2.15 per 1,000 person-years in the United States[8]. In this report by Waterman *et al.*, the incidence of ankle sprain in players aged 15 and 19 years was 7.2 per 1,000 person-years[8]. The rate in the present study was higher than that in the study by Waterman[8]. Children in elementary and junior high schools are more involved in sports compared with the general population. This fact might affect the results.

In the present study, ankle sprain occurred significantly frequently among basketball and soccer players. Similarly, in the report by Waterman *et al.*, basketball (41.1%), football (9.3%), and soccer (7.9%) were associated with the highest percentage of ankle sprains[8]. Moreover, Fong reported that rugby, soccer, volleyball, handball, and basketball were associated with ankle sprain[9].

In the present study, ankle stiffness was a risk factor for ankle sprain. Johanson *et al.* suggested that subtalar joint supination has a close relationship with limitations in ankle dorsiflexion[10]. Edo *et al.* reported that supinated subtalar joint causes lateral loading of body weight on the foot, which is a risk factor for inversion ankle sprain. Based on these two studies, it can be hypothesized that students who have stiff ankles more frequently have supinated subtalar joint than students who have normal ankles. This might be the reason for the higher frequency of ankle inversion sprains among students who have stiff ankles.

Similar to the present study, Tabrizi *et al.* reported a strong association between decreased ankle dorsiflexion and injury in children[11]. By contrast, Extrand *et al.* reported that there was no correlation between past injuries and existing muscle tightness among soccer players[12]. Denegar *et al.* also reported that there were no significant differences in any of the ankle dorsiflexion measurements between injured and uninjured ankles[13]. However, since these two reports were retrospective studies and the present study was a prospective trial, there were differences in the interpretation of the results. In a retrospective study, the results of the analysis of ankle sprain might affect the quality of physical examination. Although it is difficult to conclude, the limitations in ankle dorsiflexion is not only the cause of ankle sprain but also a risk factor for ankle sprain. If the limited dorsiflexion is a risk factor for sprain, improvements in ankle ROM might prevent the occurrence of ankle sprain.

In the present study, the incidence of fracture was 105/3,755 (2.8%). Rennie *et al.* reported that the incidence of fractures in Edinburgh, Scotland, was 20.2/1,000/year and that 61% of fractures occurred in boys[14]. The incidence of fracture and the tendency of a high rate in boys are similar to those reported in the present study. Landin *et al.* reported that 10–25% of all pediatric injuries are more common in boys than in girls and are twice as common after the age of 13 or 14 years[15]. The tendency of a high rate in boys and older children is similar to that reported in the present study.

Mervi *et al.* reported that an increase in fracture incidence was observed from 1967 to 1983, but a significant decrease was noted from 1983 to 2005[16]. However, a contrasting situation was reported in Japan; the incidence of bone fracture more than doubled within 30 years, from 1970 through 2000[3].

In the present study, since the number of students involved in sports was higher in the fracture group, sports activity is considered one of the risk factors for fracture. Similarly, Clark *et al.* proposed that the risk of fracture from vigorous physical activity outweighs the beneficial effects of osteogenic stimulation, compared with children who only perform less vigorous physical activities[17]. By contrast, Detter *et al.* reported that exercise programs improved the bone mass and size without affecting the fracture risk[18].

In the present study, the number of basketball and kendo players was significantly higher in the fracture group. Randsborg *et al.* reported that snowboarding was associated with the highest activity-specific fracture rate, which was estimated to be 1.9 fractures per 10,000 hours of exposure. The fracture rates per 10,000 hr of exposure were 0.79 for handball, 0.44 for soccer, and 0.35 for trampolining[19]. The type of exercises differed from those in the present study. The differences in the type of sports probably affected this result. For example, very few students were involved in snowboarding in the current study; therefore, snowboarding was excluded from the present study.

The number of students who are not involved in sports activity was significantly higher in the non-sprain group than in the sprain group. However, between the fracture and non-fracture groups, the difference in the number of students not involved in sports activities was not significant. The duration of sports activity per week tended to be longer in the sprain group than in the fracture group, but it was not significant (Student's t-test, P=0.055). Based on these results, it was suggested that ankle sprain has a closer relationship with sports than with fracture.

Kaewpornsawan *et al.* reported that 87.1% of fractures were caused by falling (34.6%), road accidents (28.4%), and falling from heights (24.1%)[20]. Waterman *et al.* reported that nearly half of all ankle sprains (49.3%) occurred during athletic activities[8]. Based on these two reports, in line with those of the present study, ankle sprain has a closer association with sports activity than with fracture. Although sports activity is one of the risk factors for injury, it is not advisable to avoid indulging in sports because of the fact that sports activities provide various physical, psychological, and social benefits[21]. For children aged 5–17 years, the World Health Organization (WHO) recommended >60 min of exercise per day to improve physical health[22]. However, in Japan, the duration of physical education in elementary and junior high schools is 2–3 hr per week[23]. In accordance with the recommendations of the WHO, physical activity in addition to physical education time in school is desirable. It would be ideal to conduct sports activities that do not increase the risk of injury and thereby enjoy various benefits. Hence, the body and the environment should be prepared to prevent injury and to avoid getting hurt, thereby receiving various benefits from sports with minimum risk of injury. Parkkari *et al.* reported that general injury can be reduced via prevention programs and ankle disk training, combined with thorough warm-up. In high-risk sports, ankle sprain can be reduced using ankle supports[24].

There are several limitations of this study. Although examination of the physical findings of the students are directly performed by an orthopedic surgeon, the examination is still considered as a screening procedure. Screening examination has to be accomplished in a timely manner. Therefore, evaluation of ROM quantitatively is impossible using our method. Only qualitative evaluation was possible. In addition, a follow-up study was only performed for 1 year, which is relatively short. Further follow-up is desired to evaluate the relationship between physical findings and musculoskeletal problem.

Conclusion

This study examined the relationship between physical findings and injuries. In the injury group, the number of male students; number of students involved in longer exercise time; number of soccer, basketball, badminton, kendo, and baseball players; and students with stiff ankles and elbows were significantly high. Ankle stiffness was a risk factor of ankle sprain.

Considering the merits we can obtain from sports, not involving in sports to prevent injury is a misplaced idea. It is important to continue performing exercise without injury. Selecting low-risk sports, such as swimming, is one of the strategies for prevention of injury. However, since personality and preferred sports differed from one individual to another, requiring all students to participate in swimming is not a realistic solution.

To prevent injury, involvement in sports at an appropriate time and environment is important. Improving an individual's physical condition that can lead to injury such as ankle stiffness is also important.

Conflict of interest: The authors declare that they have no conflict of interest.

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